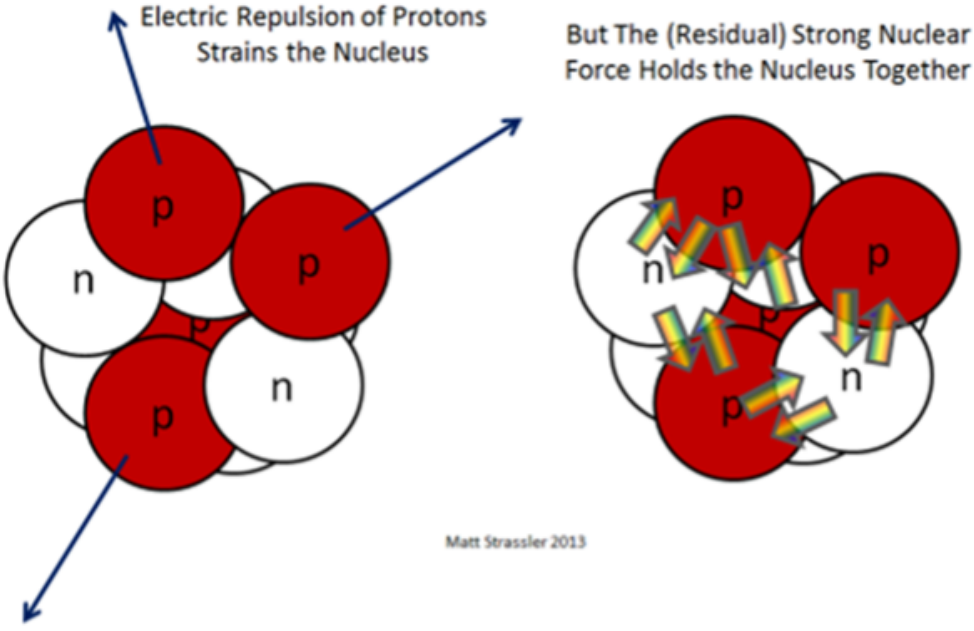
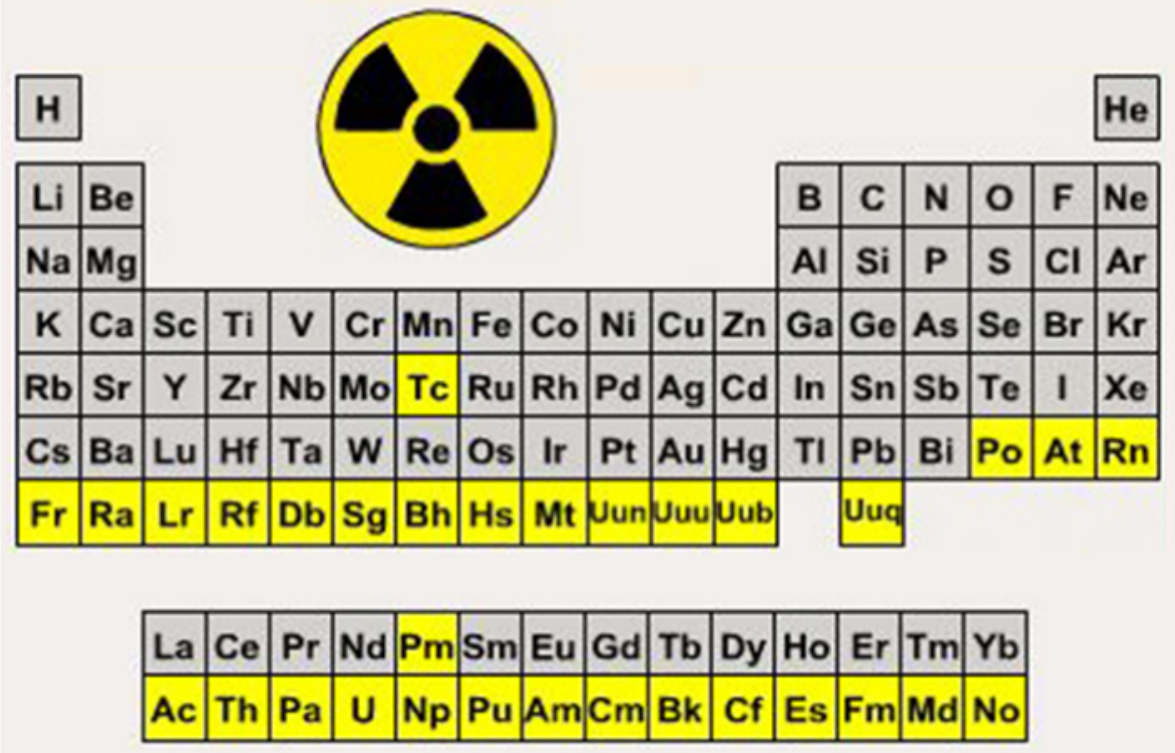
Nuclear Energy:

- Nuclear Stability
  - Depends on inter-nuclear forces acting on protons and neutrons
  - Protons have charge; electric force tries to separate protons
  - Strong force holds protons/neutrons together

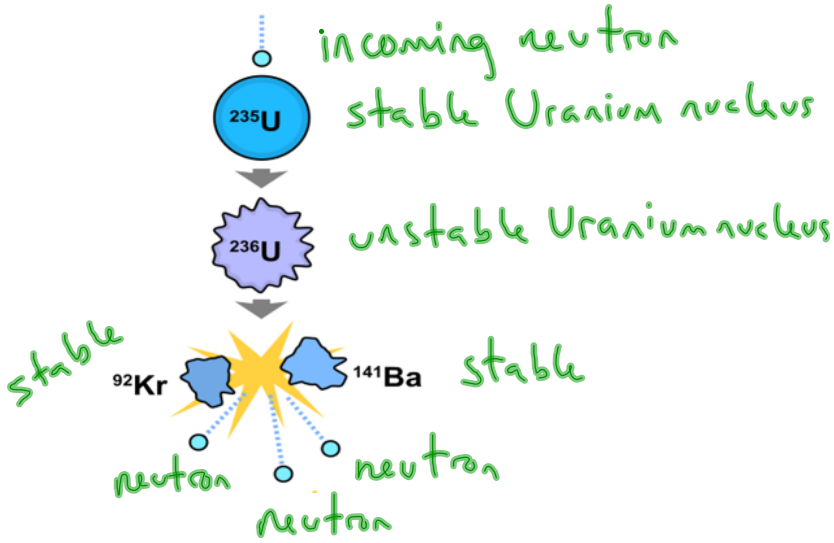




- Unstable when too many protons or neutrons → atom will split to "try" to become stable

- At least one isotope of atoms with more than 83 protons is unstable

- Fission
  - Process where a nucleus splits into two or more smaller fragments, releasing neutrons and energy
  - Happens in large nuclei



  - Multiple pathways for nuclei to decay
  - 3 products produced in all paths

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow \left[{}^{236}_{92}U\right] \longrightarrow \begin{cases} {}^{140}_{56}Ba + {}^{93}_{36}Kr + 3{}^{1}_{0}n \\ {}^{144}_{55}Cs + {}^{90}_{37}Rb + 2{}^{1}_{0}n \\ {}^{144}_{54}Xe + {}^{90}_{38}Sr + 2{}^{1}_{0}n \\ {}^{146}_{57}La + {}^{87}_{35}Br + 3{}^{1}_{0}n \\ {}^{160}_{62}Sm + {}^{72}_{30}Zn + 4{}^{1}_{0}n \end{cases}$$

- Energy Released
  - In a fission reaction, mass decreases → energy released
  - $E = mc^2$ $(c = 3E8\ m/s)$
  - Converting 1 kg of ^{235}U into energy:

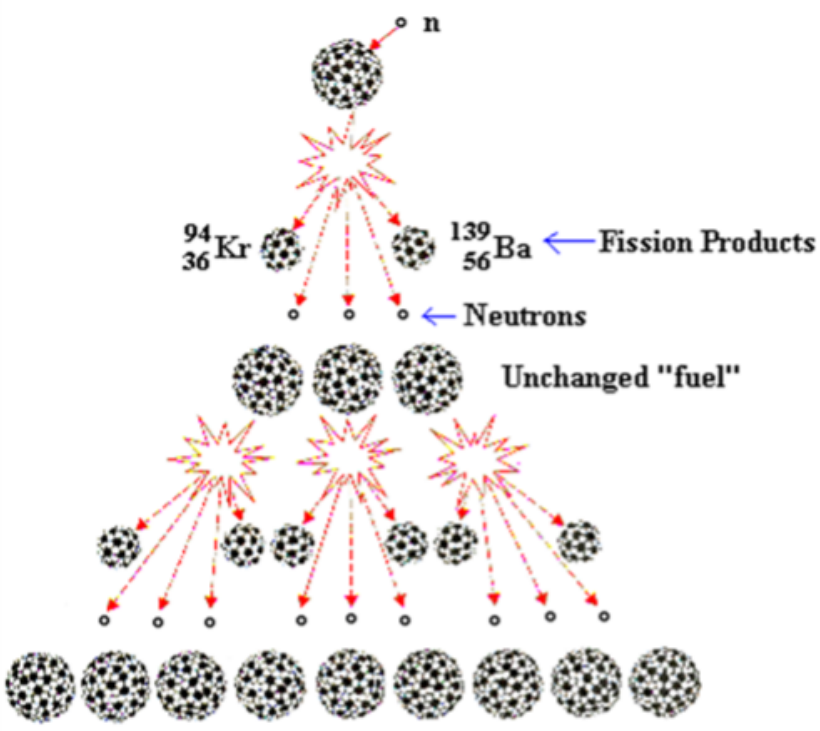
$$E = (1\ kg)(3E8\ m/s)^2$$

$$= 9E16\ J$$

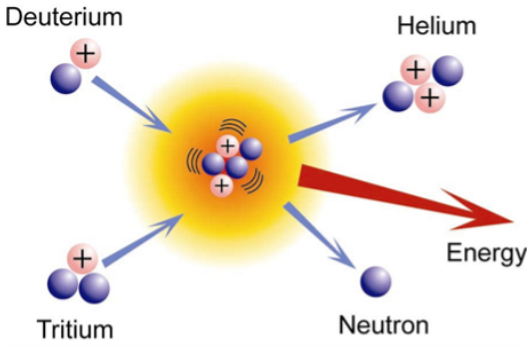
  - Compared to 1 kg of coal:

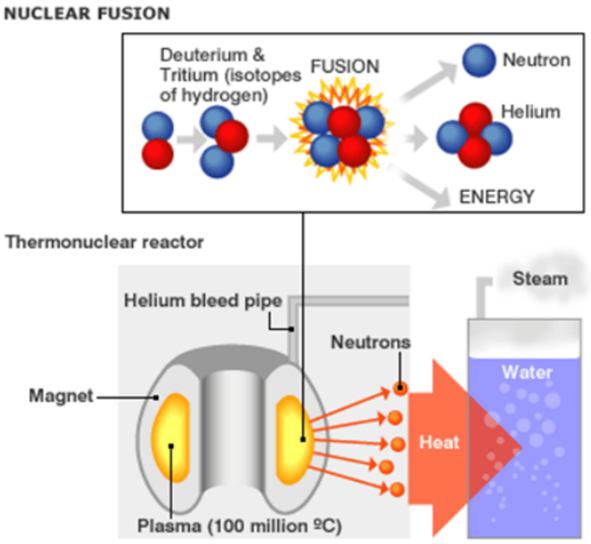
$$E = 3.1E7\ J$$

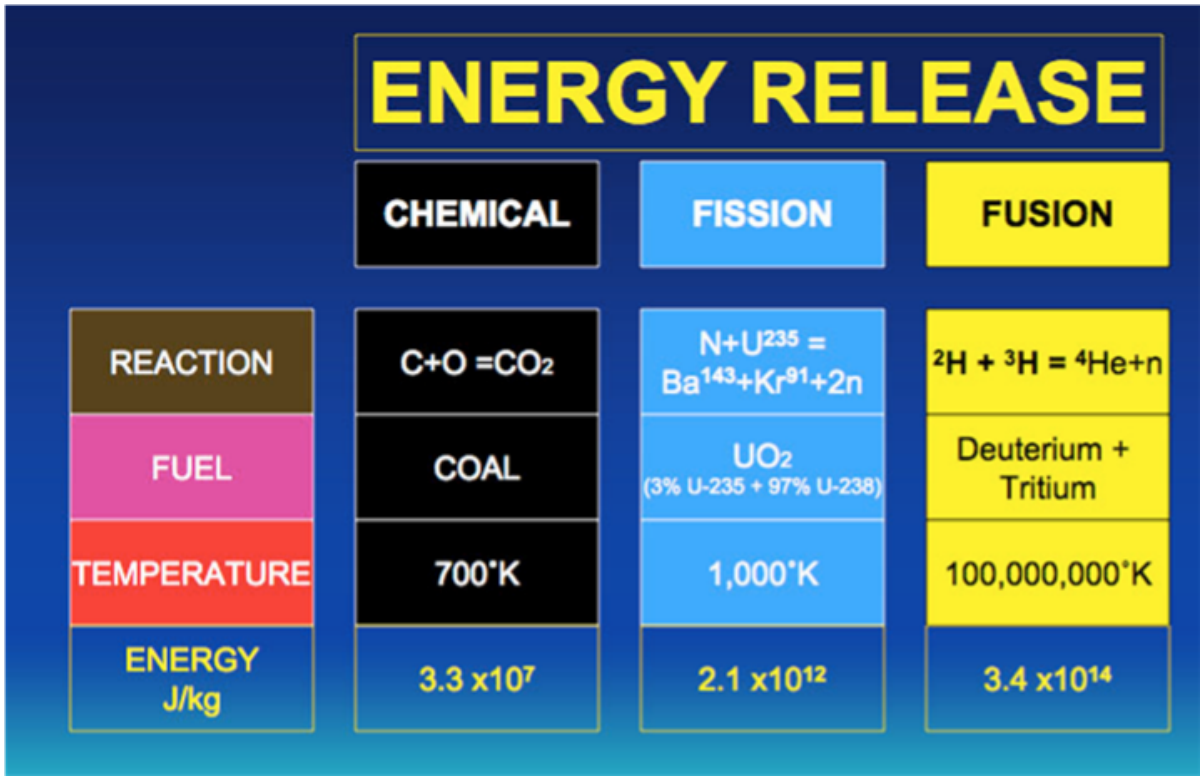
- Chain Reaction:
  - Repeating fission process
  - Neutrons from one reaction cause another reaction
  - Controlled → power plant/submarine/aircraft carrier
  - Uncontrolled → nuclear weapon



- Fusion
  - Two light nuclei combine to form a heavier atom
  - Simplest version






ENERGY RELEASE
CHEMICAL
FISSION
FUSION
REACTION
C+O =CO2
N+U235 = Ba143+Kr91+2n
2H + 3H = 4He+n
FUEL
COAL
UO2
(3% U-235 + 97% U-238)
Deuterium + Tritium
TEMPERATURE
700˚K
1,000˚K
100,000,000˚K
ENERGY J/kg
3.3 x107
2.1 x1012
3.4 x1014